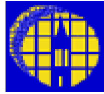
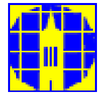


Lab Manual



NanoSpec Film Thickness Measurement System

(nanospec)

1.0 Title

NanoSpec Film Thickness Measurement System (NanoSpec)

2.0 Purpose

The Nanospec®/AFT Model 3000 is a computerized film thickness measurement system. It includes a computer controlled grating monochromator and a photomultiplier tube detector. The film thickness is calculated based on the interference spectra generated, when the light passing thru the film, using one of several proprietary algorithms. The NanoSpec offers fast measurements and multilayer film capability.

3.0 Scope

This manual covers the operating procedure of film thickness measurement, available measurement programs for various film stacks, and user level trouble-shooting guide.

4.0 Applicable Documents

Revision History

Nanometrics AFT Operations Manual (copy in Office)

5.0 Definitions & Process Terminology

N/A

6.0 Safety

6.1 **Burn Hazard:** The light source is hot. Be careful when aligning the light bulb.

6.2 **Strong Light Hazard:** Do not look into the light source directly for a long period of time.

7.0 Statistical/Process Data

Nanospec is tested by process staff monthly using standard wafers, and the results are posted on the WAND (Equipment Problem).

8.0 Available Processes, Gases, Process Notes

8.1 Standard programs provided by the instrument vendor are listed in Appendix 12.1.

8.2 In order to measure the film thickness, the refractive index and extinctive coefficient of the film are needed. The instrument vendor provided these data of various films, which are listed in Appendix 12.2.

8.3 Nanospec can only measure transparent films. Metal films and thick Germanium/Silicon films cannot be measured.

8.4 Contact process staff to set new measurement program if needed.

9.0 ***Equipment Operation***

System Description

9.1 The Nanospec system consists of a customized optical microscope and a personal computer with Windows OS.

9.2 The optical microscope has a computerized spectrophotometer head and a dual wafer stage, left side for the reference wafer and right side for the sample to be measured. The microscope has three objective lenses: 5X, 10X (default), and 50X magnifications. There are three tabs on the light path of the microscope. Their functions are described below.

9.2.1 Field: Labeled with “F”. It can be rotated to change the size of the octagon in the field of view. The octagon is used for focusing when measuring blank sample without patterns and the reference wafers. It may be difficult to focus on all eight edges of the octagon. The user can just pick one edge for focusing. Then repeat on the same edge for consistent measurement results.

9.2.2 Aperture: Labeled with “A”. It controls the light intensity and usually needs no adjusting.

9.2.3 Filter: not labeled tab that moves left or right. It inserts a yellow color filter in the light path to prevent light exposure, when measuring photo-resist.

9.3 All the system operations are controlled by clicking the GUI buttons showed on the personal computer screen. Most used GUI buttons are listed in the following sections.

9.3.1 CALIB Stops any measurement in progress and returns to the available Program Screen. A new program is selected by double clicking on the program name. Before the selected program starts, the computer will prompt for a reference calibration sequence.

9.3.2 ENTER Terminates an alphanumeric entry. The entry is not stored in the computer until this key is clicked.

9.3.3 GRAPH Displays the measurement result in the graphic format.

9.3.4 LIST Displays all the current measurement results in the numeric table format.

9.3.5 MEAS Starts a measurement.

9.3.6 NEW TEST Clears all the previous measured data from the screen. Starts a new numeric table and statistics for the new measurements.

9.3.7 REFERNCE Starts a new reference calibration sequence without returning the CALIB screen.

9.3.8 STAT Displays the statistics for the measurement results that includes mean, range, maximum, minimum and standard deviation.

Measurement Procedures

9.4 Enable NanoSpec on the WAND.

9.5 Place the reference wafer on the left side of the stage and the sample to be measured on the right side of the stage.

9.6 Click the **CALIB** button to display all available programs on the screen. Select the program for the measurement by double clicking the program name.

9.7 The computer will prompt you to do a reference calibration. Follow the instructions.

9.7.1 When prompted to move to the “dark stage” area, use the custom made light blocker to block the light passage from source to the microscope.

9.7.2 Use the tab at the front center of the wafer stage to move the stage to the right end, so that the reference wafer is under the objective lens.

9.7.3 Use the coarse (large) and fine (small) knobs at the base of the microscope to focus on the reference wafer. Do not click the **Auto Focus** on the computer screen, since this option is not installed on the tool.

9.8 After the reference calibration, the tool is ready to make measurements.

9.8.1 Use the tab on the front center of the wafer stage to move the stage to the left end, so that the sample is under the objective lens.

9.8.2 Focus on the sample. Move the wafer stage using the X-Y axis knobs under the stage.

9.8.3 When measuring patterned sample, make sure the black dot, which marks the active optical area, in the center of the objective lens is well within the center of the patterned feature to be measured. The actual dot size depends on the magnification of the objective lens.

Objective Magnification	Meas. Dot Size (μm)
5X	50
10X	25
50X	5

Note: If you need to change the objective magnification now, you have to redo the reference calibration again. Use the same magnification for the calibration as for the sample measurement.

9.8.4 Click **MEAS** button to make a measurement. The computer screen will show the result, which includes the thickness of the film measured and the goodness of fit for the measurement.

The goodness of fit is a unit-less number, which represents how the measurement algorithm converges. The smaller the value is, the better it converges. Usually, the goodness of fit should be less than 0.1 for single layer film less than 3000 Å, and less than 5 for double layer film.

To ensure the sanity of the measurement, you should click the **GRAPH** button to see how the measurement algorithm fit with the actual spectrum (red and blue curves overlap each other or basically track each other). This means when the peaks and valleys of the spectrum fit well, the measurement should be correct. See Section 10.0 below if the spectrum does not fit.

9.8.5 Write down the data since there is no printer attached to the tool. Disable the tool on WAND when you are done.

10.0 ***Troubleshooting Guidelines***

10.1 Problem**:** **Computer does not respond to the keyboard or mouse.**

Cause: Computer OS/hardware problem.

Solution: Reset the computer by switching it off/on.

10.2 Problem: **The measurement results are the same even the measurement spot has been changed.**

Cause: Computer software problem.

Solution: Reset the computer by holding down [Ctrl], [Alt], and [Del] keys together.

10.3 Problem: **The measurement spectrum does not agree with the computer algorithm.**

Cause: The reference calibration was not done correctly.

Solution: Click the **REFERNCE** button and re-start the calibration. If a problem persists, you may need to HF dip the reference wafer to remove possible oxide on it.

10.4 Problem: **Cannot find the octagon for focusing.**

Cause: Previous user opened up the field for the pattern sample.

Solution: Rotate the Field tab, labeled with "F", on the light path of the microscope until you see the octagon again.

10.5 Problem: **No light in the microscope.**

Cause: Light bulb burned down or power source turned off.

Solution: Report the problem on the WAND.

11.0 Figures & Schematics

N/A

12.0 Appendices

12.1 Standard Program

Prog #	Film to be measured	Range (Å)	Note
1	Oxide on Silicon (10X)	400 - 50,000	Not accurate for highly doped PSG
2	Nitride on Silicon (10X)	400 - 40,000	Use customized LSN program for Tystar17 film
3	Negative Resist on Silicon (10X)	500 - 40,000	Hard bake and plasma will change the accuracy
4	Polysilicon on 1000Å Oxide (10X)	550 - 10,000	The oxide should be in the range of ± 200Å
5	Negative Resist on 1000Å Oxide (10X)	4,000 - 30,000	
6	Nitride on 1000Å Oxide (10X)	300 - 3,500	
7	Thin Oxide on Silicon (10X)	100 - 500	Focusing is critical to the measurement repeatability
8	Thin Nitride on Silicon (10X)	100 - 500	Focusing is critical to the measurement repeatability
9	Polyimide on Silicon (10X)	500 - 30,000	
10	Positive Resist on Silicon (10X)	500 - 40,000	Resists have different refractive index, default 1.64
11	Positive Resist on 1000Å Oxide (10X)	4,000 - 30,000	Resists have different refractive index, default 1.64
12	Reflectance Mode (10X)		Result in % compared to the reference wafer
13	Thick Oxide (10X)	>40,000	

12.2 Available Material for Measurement Program Setup

	Materials		Materials
000	Air	023	Diamond (C) -Book
001	Crystal Silicon -Book	024	Water - Book
002	Silicon Dioxide -Book	025	Aluminum Oxide -Book
003	Silicon Nitride -Book	026	TiO2 Book
004	Negative Resist	027	Tungsten (W) -Book
005	Positive Resist	028	Silicon Carbide -Book
006	Amorphous Silicon	029	GaAs -Book
007	Polymide	030	Aluminum -Book
008	Polysilicon	031	Chromium (Cr) -Book
009	Silicon (480-900 nm)	032	Amorphous Silicon -Book
010	Silicon (visible)	033	Platinum (pt) -Book
011	Chromium (Cr)	034	Tantalum (Ta) -Book
012	Cr2O3	035	Nickel (Ni) -Book
013	Poly-silicon	036	Molybdenum (Mo) -Book
014	UV Oxide	037	Titan Carbide (TiC) -Book
015	UV Nitride	038	Graphite (C) -Book
016	NiFe	039	LiNb03 -Book
017	WSi	040	Titan Nitride (TiN) -Book
018	7059 Glass	041	Si Monoxide (Si0) -Book
019	Quartz	042	Ti
020	Gold (Au)	043	TiN
021	Copper (Cu) -Book	044	TiSi
022	InP - Book	045	LTO